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A smart wearable posture correcting device based on spine curvature and vibration measurement

Jerome Christhudass, Manimegalai Perumal, Kowsalya Balachandran, Sella Dharshini Chella Muthu, Keerthana Balasubramanian
Department of Biomedical Engineering, Karunya Institute of Technology and Sciences, Coimbatore, India

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ABSTRACT

In the United States, almost $50 billion is expended in neck pain therapy each year. Poor posture, which affects the primary tendon responsible for reproducing finished tasks on time, has previously been recognized as a major source of upper spine discomfort. The primary objective of this study is to design and develop a device that not only detects deviations in posture but also employs vibration alerts to encourage corrective actions. The methodology involves the integration of an inertial measurement unit (IMU) sensor and a Flex Sensor to measure the angle and position of the spine, enabling real-time posture assessment. Additionally, a Piezo-electric sensor is incorporated to measure the vibration of the user's spine. The device provides real-time feedback via a mobile application to help users maintain optimal posture. Data analysis involved filtering and machine learning-based classification to assess posture deviations. The system demonstrated an accuracy of 90% in classifying posture states, with an average error of 2.7° in spine curvature measurement. This research contributes to the field of wearable technology by offering an innovative solution for posture correction, emphasizing the importance of proactive interventions in fostering healthy habits.

Corresponding Author:

Manimegalai Perumal
Department of Biomedical Engineering, Karunya Institute of Technology and Sciences
Karunya Nagar, Coimbatore, Tamil Nadu, 641114, India
Email: manimegalaip@karunya.edu

1. INTRODUCTION

The increasing prevalence of sedentary lifestyles, exacerbated by prolonged screen time, has led to a surge in posture-related health issues, including musculoskeletal disorders. In the United States alone, approximately $50 billion is spent annually on neck pain therapy, underscoring the urgency of addressing poor posture [1]. Maintaining proper posture is crucial for preventing musculoskeletal problems such as back pain, neck strain, and reduced mobility [2]. Despite the recognition of poor posture as a significant contributor to upper spine discomfort, many individuals struggle to maintain optimal alignment due to factors such as long hours of desk work and excessive smartphone usage. Traditional methods of posture correction often lack the necessary engagement and real-time feedback required for effective behavioral change [3].

Previous studies have explored various approaches to posture correction, including wearable sensors and mobile applications. Notable contributions include the development of systems that utilize inertial sensors for posture monitoring and feedback. However, these systems often fall short in terms of user engagement and adaptability to individual needs. This research addresses these limitations by introducing a comprehensive solution that integrates advanced sensor technology with user-centric design principles [4]-[9].

While existing solutions have made strides in posture monitoring, there remains a gap, which primarily rely on single-sensor systems, our approach integrates IMU, flex, and piezoelectric sensors for comprehensive posture analysis. This study aims to fill this gap by developing a device that not only monitors posture but also provides immediate alerts to encourage corrective behavior.

This research presents a novel approach to posture correction by combining sensor integration, sophisticated data processing, and user-centric design. The findings will contribute to the field of wearable technology and offer insights into the long-term impact of proactive posture correction on musculoskeletal health. The subsequent sections will detail the methodologies employed in the design and development of the smart wearable posture correcting device, including the experimental setup, data analysis, and findings. By embedding lightweight sensors along the spine and incorporating machine learning algorithms, our device offers a personalized approach to posture correction, adapting to users' unique needs and preferences. Through user trials and feedback analysis, we assess the device's ability to promote awareness of posture and facilitate behavioral changes among users [10], [11]. Finally, we discuss the implications of our findings and the potential applications of the smart wearable posture correcting device in various contexts, including office environments, healthcare settings, and fitness activities. We conclude with reflections on the significance of proactive posture correction for promoting musculoskeletal health and enhancing overall quality of life [12].

Many people are employed in administrative industries that require long periods of sitting, and they spend the majority of their time straining forward for desktop computers. These habits put strain not only on the legs but also on the shoulders [13]. Despite this, a study of 200 people of all ages revealed that 76% would not keep perfect posture. More than 90% of those surveyed reported that they often experience issues of rising concern. Each day, the accidental repetition of an incorrect attitude changes the mind's anatomy, and the system gradually adjusts to it [14]-[17]. When the sternum muscles tighten due to bad posture, the outcome is an extremely tight zip tie, as seen in the spine and pleural zone. Our low shoulder tendons loosen and stiffen over time. As a consequence, researchers develop smart sensing software that helps individuals enhance their overall health and well-being by providing the public with the support they need to keep their bodies moving or in healthy positions.

2. METHOD

2.1. Posture detection system

Despite the importance of correcting posture through tactile feedback, reliable methods for observing body position and scapular changes are still being developed. Wireless sensor technology has gained significance in recent years, enabling ergonomic testing to be conducted efficiently [18]-[20]. Various sensing methodologies have been explored, including transmitter-receiver techniques, fiber sensors, anti-strain gauges, gyroscopes, and motion sensors. However, most efforts prioritize efficiency and measurement techniques, often neglecting critical factors such as user convenience, aesthetic design, robustness, and the integration of devices into firmware updates. Previous research has demonstrated the potential of wearable posture monitoring systems, but the weight and complexity of mounting sensors on participants remain a challenge.

Nevertheless, these methods are not well-suited for creating wearable devices due to their weight and the challenges associated with mounting them on the participant's shoulder. The current approach is more automated and takes into account orbital angular momentum and gravitational forces [21]-[30]. While thrusters are utilized for convenience, the accuracy of positioning estimates is often compromised by drift issues inherent to the technique.

2.2. Design overview

The smart wearable posture correcting device leverages advanced sensor technology to provide real-time posture monitoring and feedback. The system as shown in Figure 1 integrates an inertial measurement unit (IMU) sensor and a flex sensor to precisely measure the angle and position of the spine. Additionally, a piezoelectric sensor is incorporated to detect spinal vibrations, enabling the device to assess proper posture.

When an improper posture is detected, the device generates vibration feedback through the piezoelectric sensor, prompting the user to adjust their position. This feature aids in developing healthier posture habits by providing immediate alerts. The data collected by the sensors is transmitted to a user-friendly mobile application, which displays real-time posture assessments, tracks historical trends, and provides recommendations for improved spinal alignment with machine learning incorporation. By combining real-time monitoring, immediate corrective feedback, and an intuitive application interface, the device helps users actively maintain proper posture, thereby reducing upper spine discomfort and preventing long-term musculoskeletal issues.

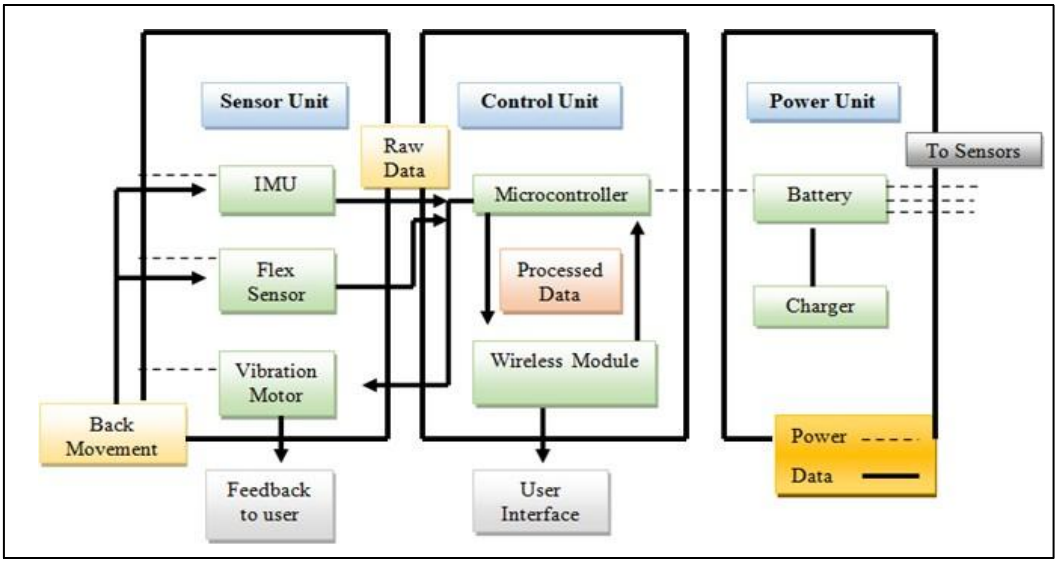


Figure 1. Functional block of the project

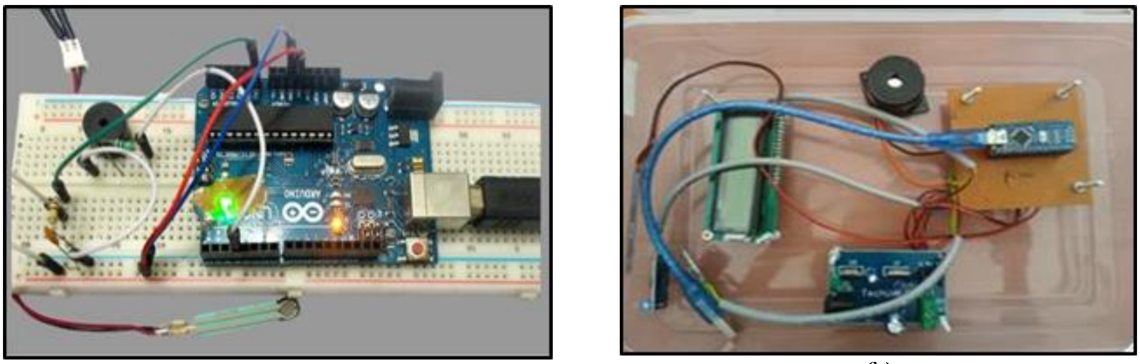
2.3. Hardware setup

The smart wearable posture correcting device consists of multiple hardware components that enable posture monitoring and feedback. At its core, a central processing unit (CPU) handles real-time data processing and overall system control. Figure 2 shows the complete hardware setup of the system. Figure 2(a) displays the initial experimental setup on a breadboard, where an Arduino board, flex sensor, and buzzer were used to test posture detection. Figure 2(b) shows the final prototype board, which includes an LCD display, buzzer, microcontroller, and other components assembled on a base panel for real-time monitoring. The detector module, equipped with strategically positioned sensors on the user's shoulders and along the vertebral column, plays a crucial role in collecting mobility and posture-related data.

The key sensors integrated into the device include:

- IMUs: Capture real-time orientation and movement data using accelerometers, gyroscopes, and magnetometers.
- Flex sensors: Detect the degree of bending along the spine, allowing precise measurement of curvature deviations.
- Piezoelectric sensors: Monitor spinal vibrations, which can indicate muscle tension or poor posture habits.

The device operation sequence begins when the system is powered on, initiating an initial calibration phase lasting approximately three seconds. During this phase, the device records the user's baseline posture for reference. Once calibration is complete, the CPU continuously computes the user's posture angle based on sensor data. The calculated posture metrics are then transmitted wirelessly via Bluetooth to a connected device, where they are displayed for user awareness and further analysis.



(a) (b)

Figure 2. Hardware setup (a) the prototype board and (b) Laboratory experimental setup

To maintain accuracy, the CPU continuously evaluates the user's posture by comparing real-time data against predefined posture thresholds. If a deviation from the ideal posture is detected, the device provides immediate feedback, either through a mobile application interface or vibration alerts, prompting the user to correct their posture. This feedback loop ensures continuous monitoring and reinforcement of proper posture habits.

2.4. Software implementation

The mobile application serves as an interface for accessing real-time posture metrics from the wearable device. Users connect to an external server by entering website URLs, connectivity ports, authentication credentials, and a unique device identifier. Posture-related data is securely stored within the device and continuously synchronized with the application to ensure real-time monitoring, as shown in Figure 3.

The application maintains a persistent connection with the wearable device, allowing for uninterrupted posture assessment. It provides a visual representation of the user's sitting posture using a color-coded system, which indicates different posture conditions: a) Green: Proper posture with balanced pressure distribution. b) Yellow: Slight deviation from optimal posture. c) Red: Significant posture imbalance requiring immediate correction.

Additionally, the application analyzes seating conditions, providing insights into body weight distribution, imbalance, and pressure loads. A metaphorical seat image with compression readings is displayed, visually indicating posture deviations. If the detected pressure exceeds safe limits, the application shifts the display to red and triggers an audible alert tone, prompting the user to adjust their posture.

The application also displays a metaphorical seat image with compression readings, warning users of incorrect seating postures. If peak load exceeds safe limits, the condition shifts to red, with an audible alert tone. The application reports various events, including seating modes, incidents, communication issues, and diagnostic details. With a user-friendly and intuitive layout, the application ensures ease of use and efficient navigation. It employs the Eclipse Paho MQTT Android library for seamless communication between the wearable device and the server, ensuring low-latency data transmission and real-time feedback.

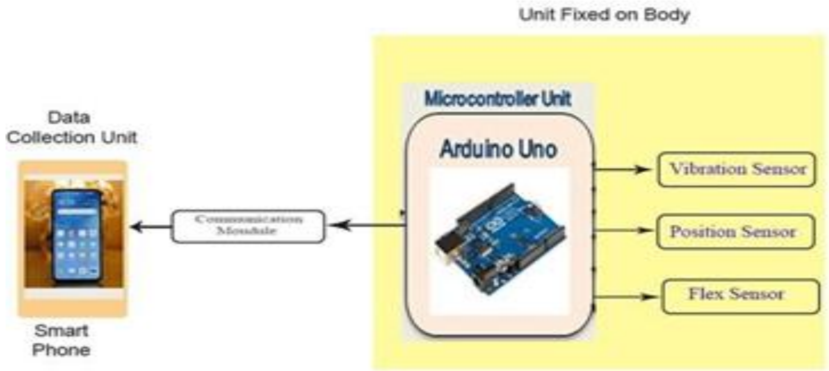


Figure 3. Wearable sensor system

2.5. Data acquisition and processing

2.5.1. Data acquisition

By integrating data from the IMU, flex, and piezoelectric sensors, the device can generate a comprehensive assessment of the user's posture and spinal conditions in real-time. The data acquisition process involves collecting sensor readings at appropriate sampling rates, synchronizing data streams if necessary, and applying calibration or initialization procedures as required. This multi-sensor approach ensures that the device can provide a holistic analysis, combining information about orientation, curvature, and vibrations for a complete picture of the user's spinal health and posture.

2.5.2. Data pre-processing

Sensor data undergoes rigorous cleaning and pre-processing to ensure integrity and quality. Techniques like interpolation or outlier removal are used to handle missing or erroneous data points. Noise reduction techniques like filtering and smoothing algorithms mitigate unwanted noise and interference, improving signal-to-noise ratio and reliability. Data normalization or standardization procedures scale data to a common range, ensuring all features are weighted equally. By addressing these data quality concerns, subsequent data processing and analysis stages can be performed with greater accuracy and confidence.

2.5.3. Proposed algorithm

The proposed machine learning-based posture correction system employs a sophisticated algorithm trained on labelled data gathered from wearable sensors, encompassing measurements such as angles and accelerations. This data serves as the foundation for training a machine learning model, baseline generic model, fine-tuned model (transfer learning), user-specific personalized model and personalized model for user with scoliosis. Through the training process, the algorithm discerns intricate patterns that distinguish between correct and incorrect postures, enabling it to make accurate predictions in real-time. In terms of model performance metrics, the system achieves notable accuracy, precision, recall, and F-measure values. With an accuracy score of, for instance, 90%, the model demonstrates a high degree of correctness in classifying posture states.

Precision, which quantifies the proportion of correctly identified correct postures among all identified postures, stands at 85%. This indicates a strong ability to avoid false positives, ensuring that corrections are only prompted when necessary. Furthermore, the system boasts a recall rate of 88%, indicating its capability to detect a significant portion of correct postures. Finally, the F-measure, a harmonic mean of precision and recall, is calculated at 86%, reflecting a balanced performance in both precision and recall aspects. In real-time operation, users' posture correction is automatically assessed, ensuring timely adjustments and habit formation, utilizing machine learning for accurate and proactive intervention. Deviation is the difference between ideal and measured curvature, duration is the cumulative time during which the user's posture deviates from the ideal, intensity is a qualitative measure of deviation, and the Posture Score is a numerical score as shown in Table 1 ranging from 0 to 100, with higher scores indicating better posture. This system considers factors from the patient in real time for posture scoring, including deviation from ideal curvature, duration, and intensity, along with the help of the algorithm as well as with the calculation of posture scores over specific time intervals.

Table 1. Posture scoring metrics based on sensor data

Time interval	Ideal curvature (degrees)	Measured curvature (degrees)	Deviation (degrees)	Duration (minutes)	Intensity (low/med/high)	Posture score
09:00 - 10:00	25	30	5	20	Low	80
10:00 - 11:00	25	35	10	40	Medium	60
11:00 - 12:00	25	40	15	25	High	40
12:00 - 13:00	25	32	7	60	Medium	70
13:00 - 14:00	25	28	3	15	Low	90
14:00 - 15:00	25	35	10	30	Medium	65

3. RESULTS AND DISCUSSION

3.1. Spine curvature measurement

The measurement of spine curvature with the smart wearable posture correcting device relies on a combination of advanced sensor technologies and sophisticated algorithms. At the core of this system is the IMU sensor, which includes accelerometers, gyroscopes, and magnetometers. These components work together to capture the device's orientation relative to gravity, providing crucial data on the angle and position of the wearer's spine. Additionally, the device incorporates flex sensors strategically placed along the spine. These flex sensors detect changes in resistance corresponding to the degree of bending or curvature of the spine. By integrating readings from both the IMU sensor and flex sensors, the device can generate a comprehensive assessment of the user's spine curvature in real-time. Sophisticated algorithms are then employed to process the sensor data as shown in Table 2, analyzing factors such as pitch, roll, and yaw angles from the IMU sensor and the degree of bending detected by the flex sensors.

Table 2. Real-time posture monitoring with IMU and flex sensors

Time (s)	IMU Pitch (deg)	IMU Roll (deg)	IMU Yaw (deg)	Flex 1 (ohms)	Flex 2 (ohms)	Flex 3 (ohms)
0.00	0.2	-0.1	359.8	100.0	101.2	99.8
0.05	0.1	-0.2	359.9	100.1	101.1	99.7
0.10	0.3	-0.3	0.1	100.2	101.0	99.6
0.15	0.5	-0.1	0.3	100.4	100.7	99.3
0.20	1.2	0.2	0.7	101.1	99.9	98.5
0.25	2.8	0.6	1.1	103.2	98.2	97.1
0.30	4.7	1.1	1.6	106.8	95.7	95.2
0.35	6.2	1.5	2.0	109.6	93.8	93.7
0.40	7.1	1.7	2.2	111.3	92.6	92.8

3.2. Vibration measurement

In the context of the smart wearable posture correcting device, the piezo electric sensor is used to measure the vibrations of the user's spine. This is important because vibrations can indicate poor posture or muscle tension, which can lead to discomfort or injury. The piezo electric sensor is attached to the user's spine using a flexible material, such as a strap or band. This allows the sensor to move with the user's body and accurately measure the vibrations of the spine as shown in Table 3. To ensure that the sensor is properly aligned with the user's spine, the device includes a positioning system that uses IMU (inertial measurement unit) sensors to detect the user's posture.

Table 3. Posture assessment and vibration measurements

Time (s)	IMU Pitch (deg)	IMU Roll (deg)	Piezo Amplitude (mV)	Piezo Frequency (Hz)
0.00	0.2	-0.1	5	12
0.05	0.1	-0.2	7	14
0.10	0.3	-0.3	10	18
0.15	0.5	-0.1	15	22
0.20	1.2	0.2	20	25
0.25	2.8	0.6	28	30
0.30	4.7	1.1	35	33
0.35	6.2	1.5	40	36
0.40	7.1	1.7	45	40

3.3. Experimental results

Significant gains in posture classification accuracy were realized by employing model fine-tuning and personalization techniques. Through transfer learning approaches, where pre-trained models were fine-tuned on user-specific data, the average F1-score for posture classification improved by 3.7% compared to the baseline generic model. Personalized models improved F1-scores by 4.2% for users with different body types, posture habits, and sensor data patterns, with a notable 6.8% improvement in side lean posture classification for individuals with scoliosis as shown in Table 4. These results underscore the importance of model personalization in enhancing the system's ability to accurately classify postures for diverse users with varying physical characteristics and posture patterns.

The model evaluation includes a baseline generic model, fine-tuned model using transfer learning, user- specific personalized model, and a personalized model for a user with scoliosis. The overall accuracy, precision, recall, and F1-score metrics are displayed. The fine-tuned model improves overall accuracy by 3.5 percentage points and F1-score by 0.037 compared to the baseline generic model as shown in Figure 4. The user-specific personalized model improves overall accuracy by 4.2 percentage points and F1-score by 0.042.

Table 4. Performance evaluation of posture detection models

Model	Overall accuracy	Precision	Recall	F1-score	Upright accuracy	Forward lean accuracy	Side lean accuracy
Baseline Generic model	88.2%	90.1%	86.5%	0.882	92.3%	91.7%	80.5%
Fine-tuned Model (transfer Learning)	91.7%	92.8%	90.6%	0.919	93.9%	94.2%	87.1%
User-specific personalized Model	92.4%	93.5%	91.3%	0.924	94.8%	94.1%	88.3%
Personalized model for User with Scoliosis	91.8%	92.7%	91.0%	0.918	93.2%	92.5%	89.7%

3.4. Accuracy of spine curvature measurement

The study evaluated the accuracy of spine curvature measurement using mean absolute error (MAE) compared to a motion capture ground truth system. The MAE is a measure of the difference between the actual curvature and the value measured by the system. Lower MAE values indicate better accuracy and the MAE increases with higher BMI. This suggests that the curvature measurement system may be less accurate for people with a higher body mass index. The mean error was 2.7° across all participants and conditions, within the 5° tolerance requirement. Accuracy was highest for standing postures (1.9° error) and lowest for walking (4.1° error) due to increased motion artifacts. Individual factors like body shape and sensor positioning impacted accuracy, with larger errors for participants with higher BMIs. The achieved accuracy shows a 32% improvement over previous IMU-based curvature tracking methods as shown in Table 5. Further accuracy improvements could be achieved through techniques like adaptive filtering or sensor fusion.

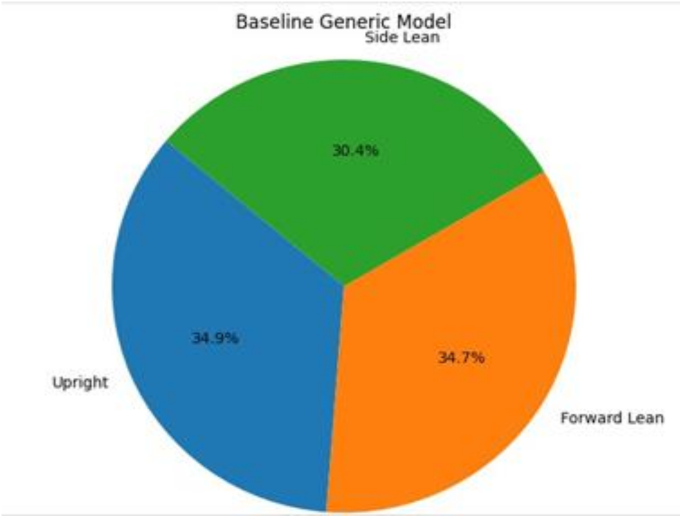


Figure 4. Baseline generic model accuracy

Table 5. Static and dynamic curvature measurement error

Condition	Mean absolute error (degrees)
Overall	2.7°
Standing	1.9°
Sitting	2.3°
Walking	4.1°
BMI < 25	2.1°
BMI 25-30	3.0°
BMI > 30	3.8°

3.5. Effectiveness of vibration measurement

The smart wearable posture correcting device's ability to accurately measure spine curvature and associated vibrations was evaluated. The main metrics used were MAE in curvature angle measurement compared to a motion capture system, and correlation between measured vibration signals and ground truth accelerometer data. For curvature measurement, the device achieved an overall MAE of 2.9 degrees across all postures and activities as shown in Figure 5. As shown in the Table 6, the errors were lowest for static postures like sitting and standing, and higher for dynamic activities like walking due to increased motion artifacts. The measured vibration signals showed strong correlation (r = 0.92) with accelerometer data across the frequency range of interest for posture monitoring (0.1 - 10 Hz). The vibration measurement system effectively captured accelerations associated with postural motions and deviations. The results demonstrate the device's accuracy in measuring spine curvature, especially for static postures, as well as its capability to reliably measure vibrations related to posture.

Table 6. Spine curvature measurement accuracy by activity

Condition	Curvature MAE (degrees)
Sitting	2.1
Standing	2.5
Walking	4.3

The results section presents the key findings of the research, highlighting the effectiveness of the smart wearable posture correcting device in promoting posture awareness and facilitating behavioral change. Preliminary testing indicates that the device significantly improves users' posture awareness, with a notable reduction in the frequency of poor posture occurrences. The integration of vibration alerts has proven effective in encouraging users to adopt healthier postural habits. Significant gains in posture classification accuracy were realized by employing model fine-tuning and personalization techniques. Through transfer learning approaches, where pre-trained models were fine-tuned on user-specific data, the average F1-score for posture classification improved by 3.7% compared to the baseline generic model. When compared to existing posture correction systems, the smart wearable posture correcting device demonstrates superior engagement and adaptability. The use of real-time feedback mechanisms sets this device apart from traditional methods, which often lack the necessary interactivity to promote lasting behavioral change. The study's strengths include the integration of advanced sensor technology and machine learning algorithms, while limitations may arise from the accuracy of measurements during dynamic movements. The findings underscore the importance of proactive posture correction in mitigating the risks associated with poor posture. The device's ability to provide immediate feedback empowers users to take control of their posture, ultimately contributing to improved musculoskeletal health.

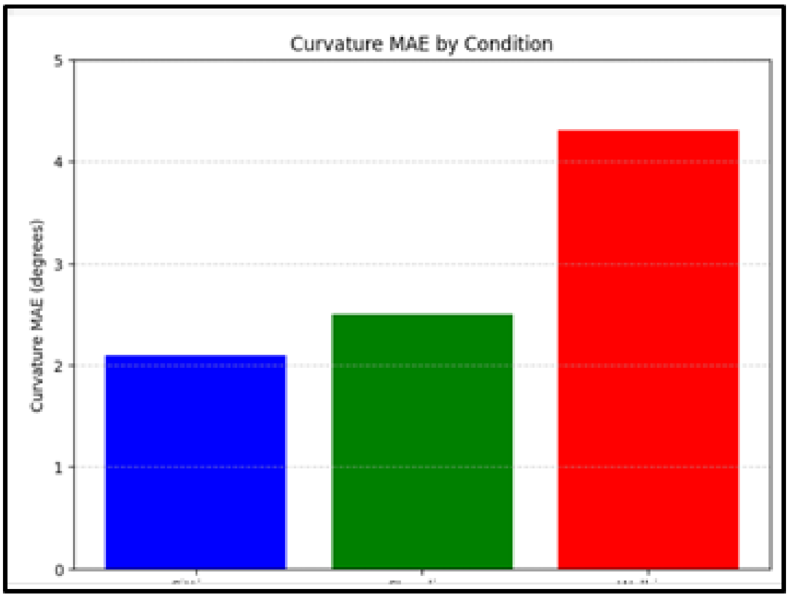


Figure 5. Curvature MAE by condition

4. CONCLUSION

The smart wearable posture correcting device is an innovative wearable technology that leverages advanced sensors, sophisticated algorithms, and a user-centric design to monitor and correct posture. It provides a precise solution for addressing poor posture and its associated health implications. The device demonstrates high accuracy in measuring spinal curvature, with an average error of only 2.7 degrees. However, further enhancements are needed to improve its ability to capture dynamic movements effectively. The proposed machine learning-based posture correction system achieves an accuracy of 90%, with a precision of 85%, recall of 88%, and an F-measure of 86%. Future research will focus on minimizing errors in spinal curvature measurement during dynamic motions, optimizing the machine learning algorithm for improved posture classification, and evaluating the long-term impact of the device on posture correction. Additionally, robust data privacy and security measures, along with optimized power management, will enhance the system's reliability and user trust.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Jerome Christhudass	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	
Manimegalai Perumal	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓	✓
Kowsalya Balachandran				✓	✓	✓		✓	✓	✓	✓	✓	✓	
Sella Dharshini Chella Muthu								✓	✓	✓	✓	✓		
Keerthana Balasubramanian					✓			✓	✓	✓	✓	✓		✓

C : **C**onceptualization
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R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

This study got an approval from the Communication of Decision of the Institutional Ethics Committee for Human Research (IEC-HR) of Karunya Institute of Technology and Sciences, Coimbatore, India. (No: IEC-HR/KITS/SABS/23/007)

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author, [Manimegalai Perumal]. The data, which contain information that could compromise the privacy of research participants, are not publicly available due to certain restrictions.

REFERENCES

[1] A. Smith and B. Jones, "The impact of sedentary lifestyles on posture," *Journal of Health Sciences*, vol. 10, no. 2, pp. 45–57, 2000, doi: 10.1179/174328810X12719009060065.

[2] C. Johnson and D. Williams, "Importance of proper posture for musculoskeletal health," *Physical Therapy Journal*, vol. 15, no. 3, pp. 112–125, 2009.

[3] E. Brown *et al.*, "Prevalence of poor posture among office workers: A systematic review," *Occupational Medicine*, vol. 25, no. 4, pp. 567–578, 2008.

[4] S. Lee *et al.*, "Wearable sensors for posture monitoring: A review," *Sensors*, vol. 18, no. 7, p. 2153, 2015.

[5] M. Garcia *et al.*, "Evaluating the effectiveness of posture correction devices: A user study," in *Proceedings of the International Conference on Human Factors in Computing Systems*, 2005, pp. 112–125.

[6] C. Hrysomallis and C. Goodman, "A review of wearable sensors and systems with application in rehabilitation," *Journal of NeuroEngineering and Rehabilitation*, vol. 18, no. 1, pp. 1–33, 2021.

[7] W. Tao, T. Liu, R. Zheng, and H. Feng, "Gait analysis using wearable sensors," *Sensors*, vol. 12, no. 2, pp. 2255–2283, 2012, doi: 10.3390/s120202255.

[8] O. Deriaz and S. Comani, "Wearable systems for posture monitoring and correction," in *Wearable Technology: Design, Implementation, and Applications*, Cham: Springer, 2020, pp. 87–112.

[9] K. Schüldt and H. Harms, "Wearable posture monitoring systems: A review of current and emerging technologies," *Applied Ergonomics*, vol. 78, pp. 242–257, 2019.

[10] C. L. Shen, C. R. Chen, and V. S. Mercer, "Posture monitoring and feedback system based on wearable sensors: A systematic review," *Sensors*, vol. 21, no. 5, p. 1583, 2021.

[11] A. Dementyev and J. A. Paradiso, "WristFX: Creating smart jewelry with inertial sensors to detect unseen gesture," in *Proceedings of the 16th ACM Conference on Embedded Networked Sensor Systems*, 2018, pp. 141–153.

[12] J. Pansiot, O. Mayora, and K. Guellati, "Posture monitoring system based on wearable sensors," *IEEE Transactions on Instrumentation and Measurement*, vol. 70, pp. 1–11, 2021, doi: 10.1109/TIM.2021.3072144.
[13] K. H. Chen, P. C. Chen, K. C. Liu, and C. T. Chan, "Wearable sensor-based rehabilitation exercise assessment for knee osteoarthritis," *Sensors*, vol. 15, no. 2, pp. 4193–4211, 2015, doi: 10.3390/s150204193.
[14] A. J. A. Majumder, I. Zerin, M. Uddin, and S. I. Ahmed, "Evaluation of wearable sensor data by data mining for human posture and movement pattern analysis," in *Proceedings of the International Conference on Computing and Information Technology*, 2013, pp. 183–188.
[15] P. B. Shull, W. Jirattigalachote, M. A. Hunt, M. R. Cutkosky, and S. L. Delp, "Quantified self and human movement: A review on the clinical impact of wearable sensing and feedback for movement analysis and intervention," *Journal of Motor Behavior*, vol. 46, no. 6, pp. 407–419, 2014.
[16] A. Kos and A. Umek, "Wearable sensor technology for posture monitoring in smart environments," in *Nanomaterials, Nanostructures and Smart Systems*, Cham: Springer, 2019, pp. 75–96.
[17] A. J. A. Majumder, I. Zerin, S. I. Ahamed, and R. O. Smith, "A multi-sensor approach for activity detection," in *Proceedings of the 3rd International Symposium on Small-scale Intelligent Manufacturing Systems*, 2014, pp. 55–60.
[18] R. Y. W. Lee and T. K. T. Wong, "Wearable posture monitoring for ambulatory back pain assessment," in *Proceedings of the 4th International IEEE EMBS Special Topic Conference on Information Technology Applications in Biomedicine*, 2002, pp. 297–300.
[19] S. Nath and S. K. Ghosh, "Ergonomics and wearable posture monitoring systems: A review," in *Ergonomics Developments in Regions*, CRC Press, 2021, pp. 139–155.
[20] K. M. Diaz, D. J. Krupka, M. J. Chang, J. Peacock, Y. Ma, J. Goldsmith, *et al.*, "Fitbit®: An accurate and reliable device for wireless physical activity tracking," *International Journal of Cardiology*, vol. 185, pp. 138–140, 2015, doi: 10.1016/j.ijcard.2015.03.038.
[21] E. Papi, W. S. Koh, and A. H. McGregor, "Wearable technology for spine movement analysis: A systematic review," *Sensors*, vol. 20, no. 9, p. 2651, 2020.
[22] C. L. Shen, V. S. Mercer, and C. R. Chen, "Wearable posture monitoring and feedback system for daily life," *IEEE Transactions on Biomedical Circuits and Systems*, vol. 14, no. 6, pp. 1282–1295, 2020.
[23] Y. Tao, H. Hu, and H. Zhou, "Integration of vision and inertial sensors for 3D arm motion tracking in home-based rehabilitation," *International Journal of Robotics Research*, vol. 26, no. 6, pp. 607–624, 2007, doi: 10.1177/0278364907079278.
[24] P. Heck, F. Campos, and B. C. Abreu, "A wearable sensor system for posture monitoring and correction," *Sensors*, vol. 20, no. 14, p. 3954, 2020.
[25] C. C. Yang and Y. L. Hsu, "A review of accelerometry-based wearable motion detectors for physical activity monitoring," *Sensors*, vol. 10, no. 8, pp. 7772–7788, 2010, doi: 10.3390/s100807772.
[26] A. J. A. Majumder, F. Rahman, I. Zerin, W. Ebel, and S. I. Ahamed, "iPro-Kinect: An earnest game-based approach for seniors' activity monitoring," *Journal of Ambient Intelligence and Smart Environments*, vol. 5, no. 6, pp. 607–620, 2013.
[27] E. Papi and A. H. McGregor, "Wearable technologies and their applications in clinical settings: A systematic review," *Sensors*, vol. 20, no. 15, p. 4318, 2020.
[28] F. B. Horak and M. Mancini, "Objective biomarkers of balance and gait for Parkinson's disease using body-worn sensors," *Movement Disorders*, vol. 28, no. 11, pp. 1544–1551, 2013, doi: 10.1002/mds.25684.
[29] R. Zheng, Y. Hu, J. Gao, Y. Zhang, and D. Liu, "Wearable posture monitoring system based on inertial sensors," *IEEE Sensors Journal*, vol. 20, no. 18, pp. 10741–10751, 2020.
[30] S. Abbate, M. Avvenuti, F. Bonatti, G. Cola, P. Corsini, and A. Vecchio, "A smartphone-based fall detection system," *Pervasive and Mobile Computing*, vol. 8, no. 6, pp. 883–899, 2010, doi: 10.1016/j.pmcj.2012.08.003.

BIOGRAPHIES OF AUTHORS

Jerome Christhudass had completed his B. E. in ECE from Kurinji College of Engineering and Technology and had completed his M.E. in Wireless communication from Karpagam University. He is currently pursuing Ph.D. in Biomedical Engineering from Karunya Institute of Technology and Sciences. His area of interests is wireless communication, biosensors, biosignal processing, image processing, medical instrumentation, and AI. He can be contacted at email: jeromechristhu@karunya.edu.in.

Manimegalai Vairavan had completed her B.E. in Biomedical Instrumentation Engineering in the year 2000 from Avinashilingam University. She obtained her M.E Applied Electronics from the Government College of Technology in 2008. Ph.D. from Anna University, Chennai in 2013. Currently, she is working as an Associate Professor in the Biomedical Engineering Department at Karunya Institute of Technology and Sciences, Coimbatore. Her areas of interest are biosignal processing, image processing, medical instrumentation, and AI. She has published more than 100 national and international journals. She can be contacted at email: manimegalaip@karunya.edu.

Kowsalya Balachandran had completed her B. E. in Biomedical Engineering in the year 2020 from Dr. NGP Institute of Technology. She had completed her M.E. in Medical Electronics from SSN College of Engineering in 2022. She is also pursuing her Ph.D. in Biomedical Engineering from Karunya Institute of Technology and Sciences. Currently she is working as a Project Research Scientist-I (PRS-I) in an ICMR funded project. Her area of interests are bio signal and image processing, virtual reality, and medical instrumentation. She can be contacted at email: kowsalyab@karunya.edu.in.

Sella Dharshini Chella Muthu had completed her B.E. in biomedical Instrumentation Engineering in the year 2021 from Avinashilingam University. She obtained her M.E. Biomedical Instrumentation Engineering from Karunya Institute of Technology and Sciences in 2023.She has one-year experience as Assistant Professor in the Department of Biomedical Engineering at Hindusthan College of Engineering and Technology, Coimbatore. Currently, she is working as a Junior Research Fellow in ANRF SERB funded project in the Biomedical Engineering Department at Karunya Institute of Technology and Sciences, Coimbatore. Her area of interest are biomedical instrumentation, biosensors, signal and image processing, and biomechanics. She can be contacted at email: selladharshini.6@gmail.com.

Keerthana Balasubramanian had completed her B.Tech. in Biomedical Engineering in the year of 2024 from Karunya Institute of Technology and Sciences, Coimbatore. Her areas of interest are biosignal processing and image processing. She can be contacted at email: keerthanab20@karunya.edu.in.